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(71) Applicant *(for all designated States except US)*: **TELEFONAKTIEBOLAGET LM ERICSSON (publ)** [SE/SE]; S-12625 Stockholm (SE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **WINBERG, Mikael, Jan, Are** [FI/FI]; Skidbacksvägen 24 B 20, FIN-00800 Helsingfors (FI).

(74) Agent: **LIND, Robert**; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).

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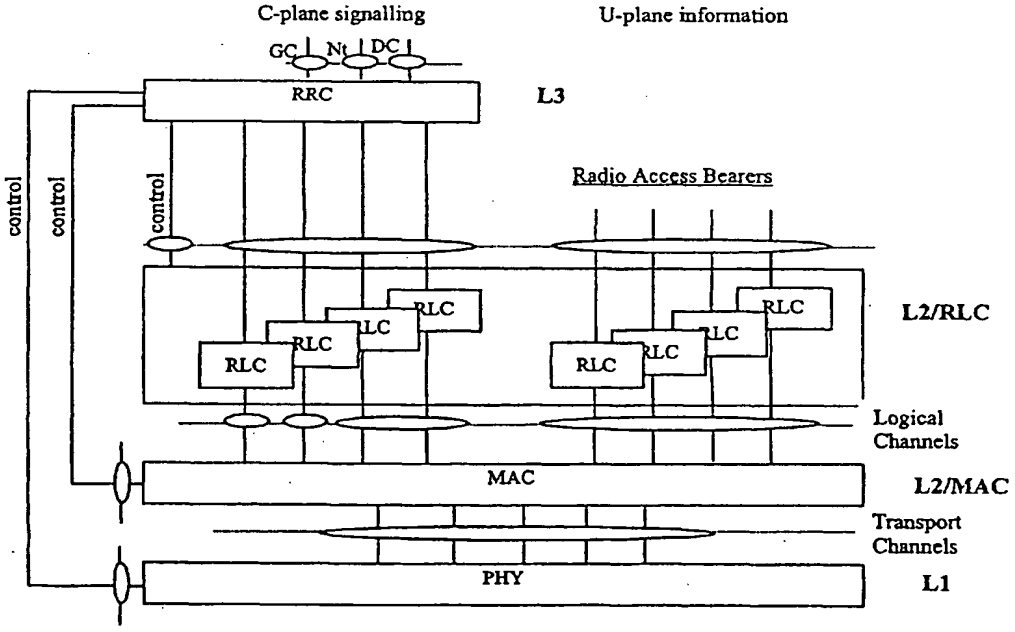
(54) Title: CHANNEL SWITCHING IN UMTS




(57) Abstract: A method of allocating transmission resources to a User Equipment (UE) at a Radio Network Controller (RNC) entity of a Universal Mobile Telecommunications System (UMTS) comprises allocating transport (dedicated or common) channels to the UE, and switching between allocated channels, on the basis of parameters which are specifically allocated to that UE. The parameters may be dynamically modified in response to previous passage of data into and out from the UE.

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# CHANNEL SWITCHING IN UMTS

## Field of the Invention

The present invention relates to data transmission in a Universal Mobile Telecommunications System (UMTS) and in particular, though not necessarily, to the allocation of transmission resources in a UMTS.

## Background to the Invention

The European Telecommunications Standardisation Institute (ETSI) is currently in the process of standardising a new set of protocols for mobile telecommunications systems. The set of protocols is known collectively as the Universal Mobile Telecommunications System (UMTS). Figure 1 illustrates a simplified UMTS layer 2 protocol structure which is involved in the communication between mobile stations (e.g. mobile telephones) and Radio Network Controllers (RNCs) of a UMTS network. The RNCs are analogous to the Base Station Controllers (BSCs) of existing GSM mobile telecommunications networks, communicating with the mobile stations via Base Transceiver Stations (BTS).

The layer 2 structure of Figure 1 consists of a set of Radio Access Bearers (RABs) which make available radio resources (and services) to user applications. For each mobile station there may be one or several RABs. Data flows (in the form of segments) from the RABs are passed to respective Radio Link Control (RLC) entities which amongst other tasks buffer the received data segments. There is one RLC entity for each RAB. In the RLC layer, RABs are mapped onto respective logical channels. A Medium Access Control (MAC) entity receives data transmitted in the logical channels and further maps logical channels onto a set of transport channels. Transport channels are finally mapped to a single physical transport channel which has a total bandwidth (<2Mbits/sec) allocated to it by the network.

A physical channel may be used exclusively by one mobile station (or UE), in which case it is referred to as a "dedicated channel" DCH. Alternatively, a physical channel

may be shared by a few users in which case the channel is referred to as a "dedicated shared channel" (DSCH). Where a channel is used by many mobile stations, each of which will send and receive data when free capacity is available, the channel is referred to as a "common channel" (FACH/RACH). A MAC entity scheduling the traffic for one UE is known as MAC-d, there being one MAC-d entity for each mobile station. A dedicated physical channel used by a UE will thus be handled by the MAC-d entity. A MAC entity connected to a common channel (FACH/RACH or DSCH) is known as MAC-c/sh. There is one MAC-c/sh entity for each cell.

UMTS allows users of mobile stations to maintain a permanent connection to a UMTS Terrestrial Radio Access Network (UTRAN). However, there are nowhere near enough transport channels for each user to be permanently assigned a dedicated channel. UMTS will generally assign such "always connected" packet data users a best effort RAB, which can be switched between common and dedicated channels, this switching being controlled by the Radio Resource Control (RRC) layer in the RNC. When the traffic volume is low, the User Equipment (UE) will be assigned a common channel with low throughput. If the traffic volume increases, the RRC allocates a dedicated channel with high throughput, and performs a channel switch.

The decision in the RNC as to whether or not to perform a channel switch is based on traffic volume measurements, RLC buffer level measurements in the UE, and RLC buffer level measurements and data throughput measurements in the RNC. More particularly, the determination of whether or not channel switching between dedicated and common channels is to take place is performed using an algorithm which uses pre-configured values (possibly changeable by the operator) for parameters such as data level thresholds and timers, these parameters being the same for all UEs. Thus, even though each UE may be monitored separately to evaluate the need for channel switching, the same threshold and timer values will apply for all UEs, regardless of possible differences in traffic behaviour.

Statement of the Invention

Different users have different requirements for data transfer frequency and intensity, and it is difficult to select suitable thresholds and timers which lead to appropriate channel allocation for all users. For example, a UE may be used frequently to check a mailbox and download attachments, with short periods of inactivity in between. If the RNC controls the channel switching using the algorithm described above, the channel allocated to the UE will be switched from a common channel to a dedicated channel every time the user begins to access the mailbox as the traffic intensity increases rapidly, and will be switched back to a common channel once the first download is complete. However, there may be only a brief pause before further downloading takes place, in which case the UE will be switched back to a dedicated channel. Thus the channel will be switched very frequently. The user experiences a considerable variation in speed, and the signalling in the network is increased in the implementation of the channel switching procedures.

In such a case it would be better to allow the UE to stay on a dedicated transport channel for as long as the mail box session continues. Then, when no downloads have occurred for a considerable time, a switch to a common channel could take place.

The inventor of the present invention has realised that, if the algorithm used by the RNC to decide when to switch UEs between dedicated and common channels uses the same parameters for all UEs, unsatisfactory allocation of channels occurs for some UEs.

It is an object of the present invention to overcome or at least mitigate the disadvantage noted in the preceding paragraph. This and other objects are achieved at least in part by allowing some or all of the parameters used to determine when a channel switch is made to be determined individually for each UE.

According to a first aspect of the present invention there is provided a method of allocating transmission resources to User Equipment (UE) at a Radio Network Controller (RNC) entity of a Universal Mobile Telecommunications System (UMTS), the method comprising:

allocating at least one transport channel to the UE; and

switching between allocated channels on the basis of parameters which are specifically allocated to that UE.

Preferably the parameters used to determine whether or not to switch between allocated channels are dynamically modified in response to the previous passage of data into and out of the UE.

Preferably the initial transport channel is one of a dedicated channel, dedicated shared channel, and a common channel, and the step of switching between allocated channels involves changing to from one of these channels to another.

According to a second aspect of the invention there is provided a method of allocating transmission resources to a UE at a RNC entity of a UMTS, the UE being allocated the use of a dedicated transport channel or access to a common transport channel for data transfer, this allocation being switchable by the RNC, the method comprising using an adaptive channel switching algorithm to adjust parameters used to determine whether or not to perform a channel switch for the UE, the adjustment being based on previous data transfer behaviour of the UE.

Some although not necessarily all of the parameters used by the channel switching algorithm can thus be individually adapted in response to the behaviour of the UE.

Preferably the parameters comprise one or more of buffer level threshold values, data throughput level threshold values, and timer values.

Preferably the channel switching evaluation function in the RNC adjusts the parameters to be used individually for each UE, within a value range configured by a network operator.

Brief Description of the Drawings

Figure 1 illustrates schematically the layer 2 of a UMTS; and

Figure 2 is a flow diagram illustrating a method of allocating channels for use by individual mobile stations.

Detailed Description of a Preferred Embodiment

As has already been described above, a simplified UMTS layer 2 consists of a Medium Access Control (MAC-d) entity for each mobile station, and a Radio Link Control (RLC) entity for each Radio Access Bearer (RAB). The MAC-d entity performs scheduling of outgoing data packets, while the RLC entities provide buffers for respective input flows. The RRC layer sets a limit on the maximum amount of data that can be transmitted from each flow by assigning a set of allowed Transport Format Combinations (TFC) to each MAC (referred to as a TFC Set or TFCS), but each MAC must independently decide how much data is transmitted from each flow by choosing the best available Transport Format Combination (TFC) from the TFCS.

The physical transport channel is referred to as a dedicated channel if it is used by only one mobile station (or User Equipment (UE)). A common channel is used by many UEs. Clearly data can be transferred more quickly by a UE if it has the use of a dedicated channel rather than sharing a common channel with many other stations. As the rate of data transfer at a UE changes, the RNC can switch the channel allocation of that UE: if the data transfer rate increases dramatically when the UE is currently allocated to a common channel, the UE may be switched to a dedicated channel. Conversely, if the data transfer rate decreases when the UE is allocated a dedicated channel, the UE may be switched to a common channel. The RNC uses an algorithm - based on traffic volume measurements in the UE and in the RNC, timers, thresholds for RLC buffer levels, and data throughput levels - to determine whether to change the allocated channel. The algorithm may be implemented in the RRC layer, or by a combination of the RRC and MAC layers (or possibly in some other layer/entity).

As previously mentioned, the use of the same algorithm and thresholds and timers for all of the UEs can lead to inappropriate and/or unnecessary channel switching for some UEs. The RNC therefore uses an algorithm with dynamically adjustable parameters for the threshold and timer values. The algorithm uses one set of parameters for each UE,

and the parameters are adjusted by a second algorithm in response to the previous behaviour of a UE.

The parameters may be set at an initial setting defined by the operator for all UEs, the intention being that they will then be adjusted for individual UEs in response to behaviour patterns. The operator may also set the range within which the parameters can vary.

To make the adjustment to the parameters, a channel switching evaluation function in the RNC observes how often channel switching is requested and how much data is transmitted on common and dedicated channels by each UE using the initial setting of the threshold and timer values.

For example, the adjustment could be designed to avoid frequent switching between dedicated and common channels during a session with variable data throughput. During a session with frequent downloads, with short periods of inactivity between the downloads, the channel switching algorithm adapts after the first few channel switches, and lowers the throughput level threshold for downswitching to a common channel, so as to allow the UE to stay on the dedicated channel. When a longer period time has passed without traffic, the algorithm returns to the initial setting and the UE is allocated a common channel.

Another example is a UE which transfers data in short bursts which are easily transmitted over the common channel (as long as the common channel is not congested). This situation may arise when a user is accessing the Internet via a web browser, requesting quite small volumes of data. Each time he requests a page there is a short burst of data transfer, which quickly ceases. After a few bursts the adaptive channel switching algorithm detects this behaviour and raises the threshold levels so as to prevent the UE being switched to a dedicated channel. If the UE then starts to transmit larger volumes of data, the channel switching algorithm returns to the initial setting, and allows the switch to a dedicated channel.

Figure 2 is a flow diagram further illustrating the method described above. Figure 2A shows the method of allocating the channel for use by a single UE, in which the parameters used may be specific to that UE. Figure 2B shows the action of the adaptive algorithm which will run in parallel with the method of Figure 2A, dynamically adapting the timers and thresholds in response to behaviour of the UE.

In order to implement the method described above, the RNC will need an additional monitoring facility to count how frequently the channel is switched for each UE. Each UE has a "context data" store associated with it which is held in the RNC for as long as the UE is active and served by that RNC. Information regarding the UE's previous behaviour – how much data is transferred and how often channel switching has occurred – can easily be added to this data store. This would then provide the information to the RNC to enable it to modify the parameters for the channel switching algorithm.

The improvement of the channel switching algorithm described above makes it easier for the operator to determine the initial channel switching threshold and timer values, as they will be dynamically adapted during use, so do not have to be precisely "fine tuned" so as to suit all UEs to begin with.

The avoidance of unnecessary channel switching gives a better service to the user, and reduces the signalling load on the network that is caused by channel switching.

There is no need to change the existing standards. This suggestion is a proprietary improvement within the standard. The RRC specification already allows measurements to be ordered in each UE using individual thresholds.

It will be appreciated that departures can be made from the preferred embodiment described above which will still fall within the scope of the invention.

CLAIMS:

1. A method of allocating transmission resources to a User Equipment (UE) at a Radio Network Controller (RNC) entity of a Universal Mobile Telecommunications System (UMTS), the method comprising:

allocating at least one transport channel to the UE, and

switching between allocated channels, on the basis of parameters which are specifically allocated to that UE.

2. A method as claimed in claim 1, wherein the parameters used to determine whether or not to switch between allocated channels are dynamically modified in response to previous passage of data into and out from the UE.

3. A method as claimed in claim 1 or 2, wherein the initial transport channel is one of a dedicated channel and a common channel, and the step of switching between allocated channels involves switching to a common channel or a dedicated channel respectively.

4. A method of allocating transmission resources to a UE at an RNC entity of a UMTS, the UE being allocated the use of a dedicated transport channel or access to a common transport channel for data transfer, this allocation being switchable by the RNC, the method comprising:

using an adaptive channel switching algorithm to adjust parameters used to determine whether or not to perform a channel switch for the UE, the adjustment being based on previous data transfer behaviour of the UE.

5. A method as claimed in any preceding claim, wherein the parameters are buffer level threshold values, data throughput level threshold values, and timer values.

6. A method as claimed in any preceding claim, wherein the channel switching evaluation function in the RNC adjusts the parameters to be used individually for each UE within a value range configured by a network operator.

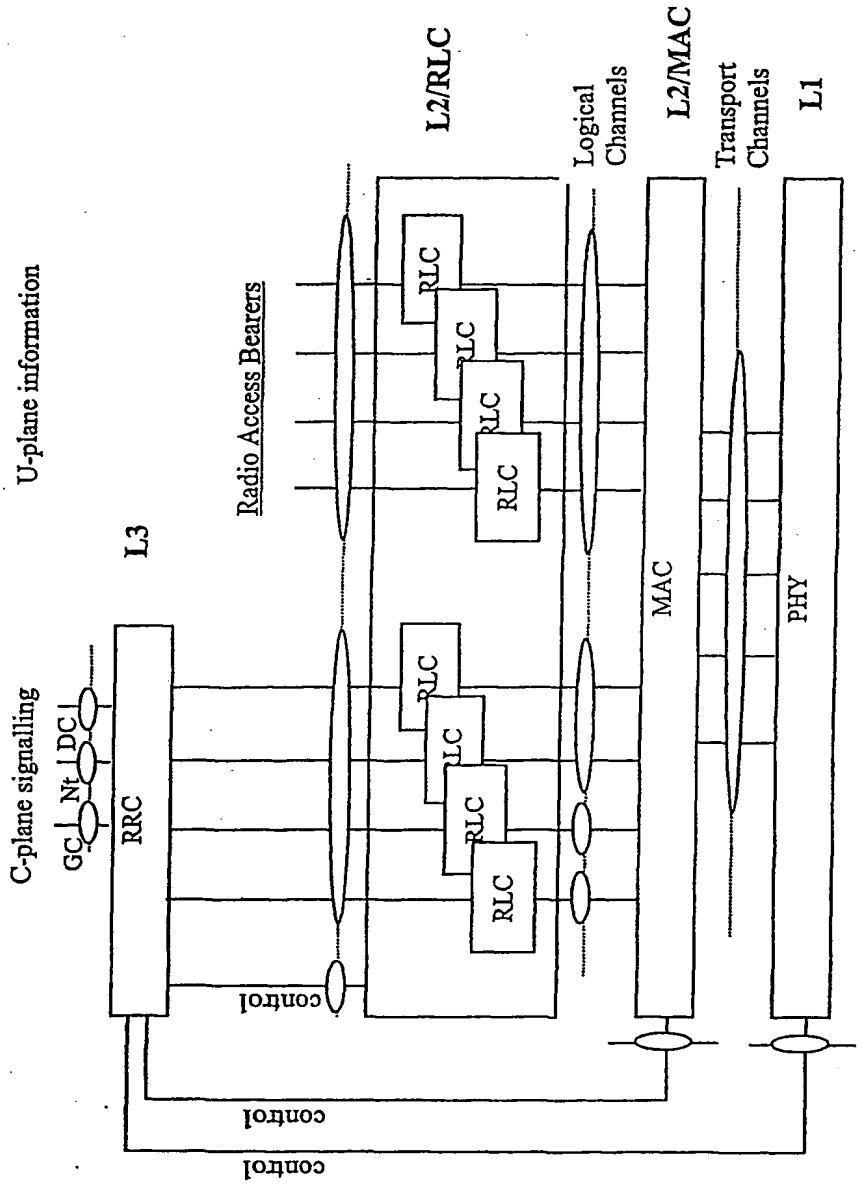
L3
L2/RLC
L2/MAC
L1
Logical Channels
Transport Channels
U-plane information
Radio Access Bearers
C-plane signalling
GC
Nt
DC
RRC
RLC
MAC
PHY
control
control
control

Figure 1

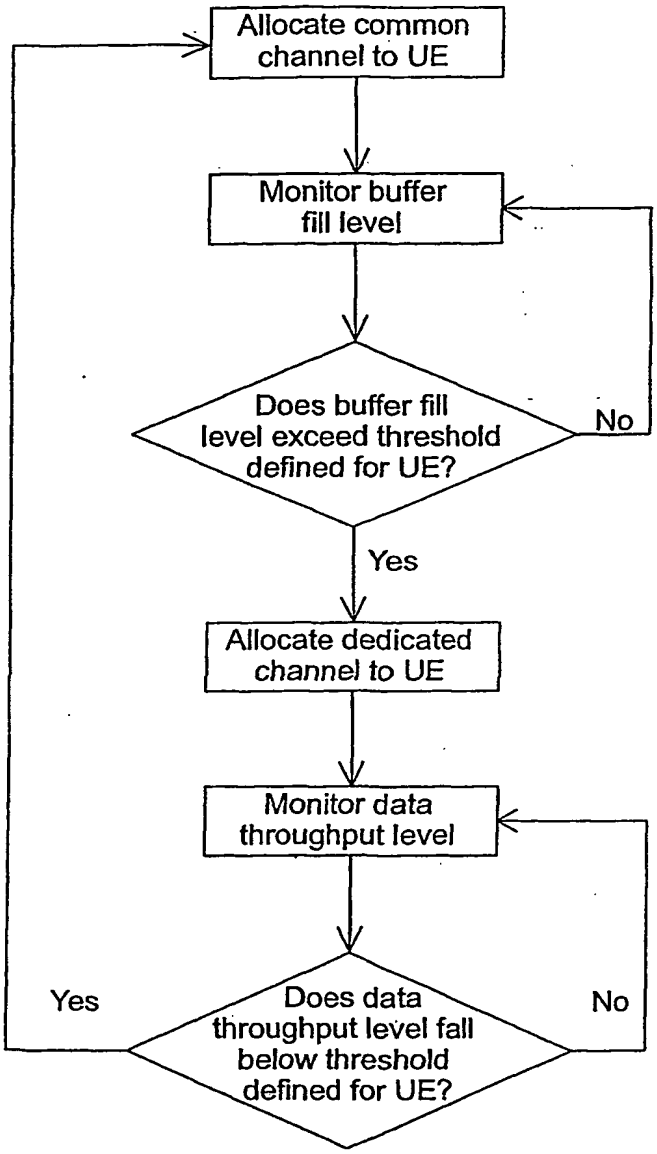


Figure 2A

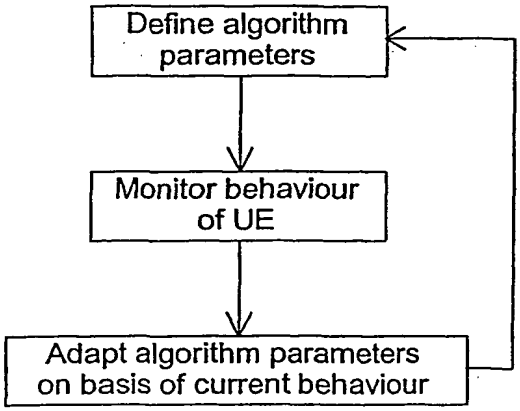


Figure 2B